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The relative quality of the concrete covering the reinforcement and the relative protection it secures.

La qualité relative du béton recouvrant les armatures et la protection relative qu'il procure.

The capability of concrete to protect the reinforcement against corrosion in a more or less agressive environment requires a certain complex quality of the concrete. It is a combination of adequate composition, density, imperviousness, low capillary suction, low absorption, low tendency to deep carbonation, low shrinkage, low tendency to cracking, and high intrinsic resistance to the agressive environment. There is no incompatibility between these properties. They may be attained by the use of good components well proportioned in the mix, good mixing and good compaction in the forms, thus good concrete and good workmanship. This adequate complex quality is assumed in an unrestricted space and one may consider it is possible to define it by a certain value. For reason of simplicity, this value will be related to itself, thus expressed by 1, which represents the strictly required quality.

In and near the cover of the reinforcement, this quality is often reduced because of the restricted space, namely multiple boundary effects from the sides and the bottom of the forms and from the reinforcement itself, sieving effect of the reinforcement and segregation, difficulty of pouring and compacting the concrete, high shrinkage stresses at the boundary of the reinforcement, etc ... This may

be represented in a diagram quoting the relative quality QU on the ordinates and the thickness C of the cover along the abscissae.

For a cover thickness C = 0, there is no concrete to protect the reinforcement, hence QU = 0. When the thickness of the cover exceeds a certain critical value CR, the effect of the restriction of the space becomes negligible and QU = 1. For the values of C between 0 and CR, QU varies according to a certain function represented on the diagram, depending of the same circumstances as the value of CR. These circumstances are : structure of the concrete, namely the maximal size of the coarse aggregate, cement content and water content,workability, compaction method, the shape and size of the reinforcement, whether the pouring and the compaction of the concrete occur parallelly or perpendicularly to the reinforcement, finally also the severity of the aggressive environment.

For example, in his book "Durability of Reinforced Concrete Wharves in Norwegian Harbours", (Oslo 1968), in which the results are related of the inspection of 716 structures exposed to the actions of the sea and the atmosphere, O.E. GJORV indicates that for concrete deposited under water by a satisfactory method, the thickness of the cover of the reinforcement should not be less than 3 times the maximal size of the coarse aggregate and at least 5 cm. (It is a case of concrete poured in a parallel direction to the reinforcement). So, in this definite case, one could admit that CR = 3 D, D being the maximal size of the coarse aggregate.

In other cases, the value of CR : D may be smaller, but surely not less than a value superior to 1, may be 1,5 to 2, according to the circumstances of the case.

Further, the protection secured to the reinforcement by the concrete may be appreciated by the product QU x C and it will again be related to 1 x CR as the expression of the strictly required protection. Hence the relative

protection PR may be expressed by PR = QU x C : 1 x CR. Its value is 1 for C = CR. For C $\succ$ CR, PR = $\frac{C}{CR} \succ 1$ and for $0 \prec C \prec CR$, PR varies in dependence of the variation of QU in the same interval, as shown on the diagram.

As it may be seen on this diagram, every increase of C on CR is proportionally beneficial, but any reduction is more than proportionally detrimental.

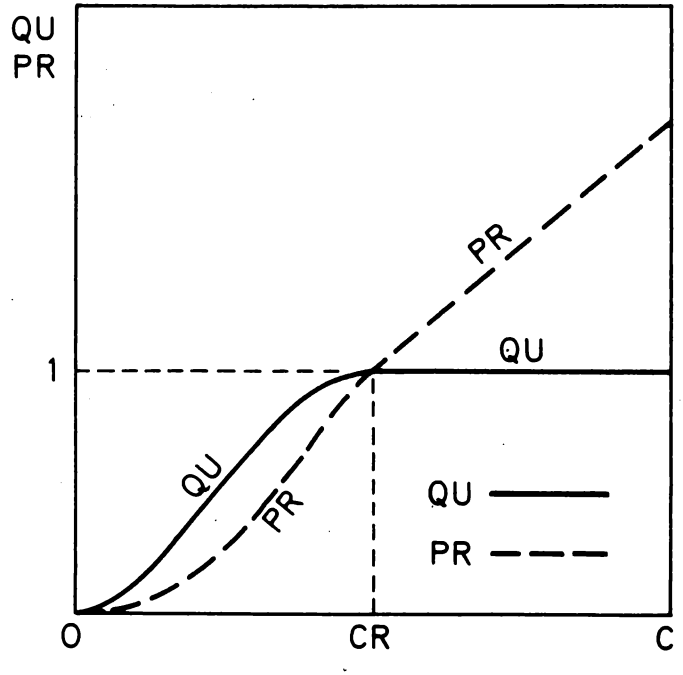

Fig. 1.

This representation is certainly more qualitative than quantitative, but it may claim, if not a convincing character, at least, a clarification for practicioners and

and even perhaps specialists of the effect of the thickness of the cover on the protection of the reinforcement by the concrete. It should perhaps become truly quantitative if a kind of characteristic test could be found to prove in some synthetic way the complex capability of concrete to protect the reinforcement against corrosion. The paper of Dr. LEVITT to this symposium deserves a great attention in this respect, as also the vivid interest proved by the participants in general for absorption and porosity. In my opinion, this gives hope that some test on the depth of absorption or similar could make it possible to measure numbers for the relative quality QU and the relative protection PR.